WE START WITH YES.

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VTO PROGRAM BENEFITS ANALYSIS

THOMAS STEPHENS
Principal Transportation Systems Analyst
Argonne National laboratory

Vehicle Technologies Office - 2018 Annual Merit Review
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Project VAN018

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

Ongoing project prior to FY 2017

Project start: 1 Oct 2016

Project end: 30 Sep 2019

Barriers

- Relating component-level technologies to national-level benefits
- Indicators and methodology for evaluating benefits

Budget

FY 2017: $238k

FY 2018: $229k

(100% DOE)

Partners

- Interactions / Collaborations
  - Oak Ridge National Laboratory
  - National Renewable Energy Laboratory
  - Sandia National Laboratories
  - Energetics, Inc.
  - Lawrence Berkeley National Laboratory
  - Univ of California at Berkeley

Relevance

Objective

Estimate potential future benefits attributable to the VTO Program, including reductions in

- Petroleum use
- Consumer costs, oil security costs
- Emissions

VTO uses results of this analysis to communicate the benefits of the program to DOE management, other agencies, Congress and others.

Compare two scenarios, with and without successful deployment of VTO technologies

- Program Success: Vehicles meet VTO performance, fuel economy and cost targets
  - Vehicle component cost and performance based on VTO/FCTO program targets, projected to 2050
  - Vehicle attributes estimated from component attributes
- Baseline (No Program): Without VTO technology improvements
  - Vehicles simulated on the basis of VTO & FCTO inputs for "No Program"

Relevance

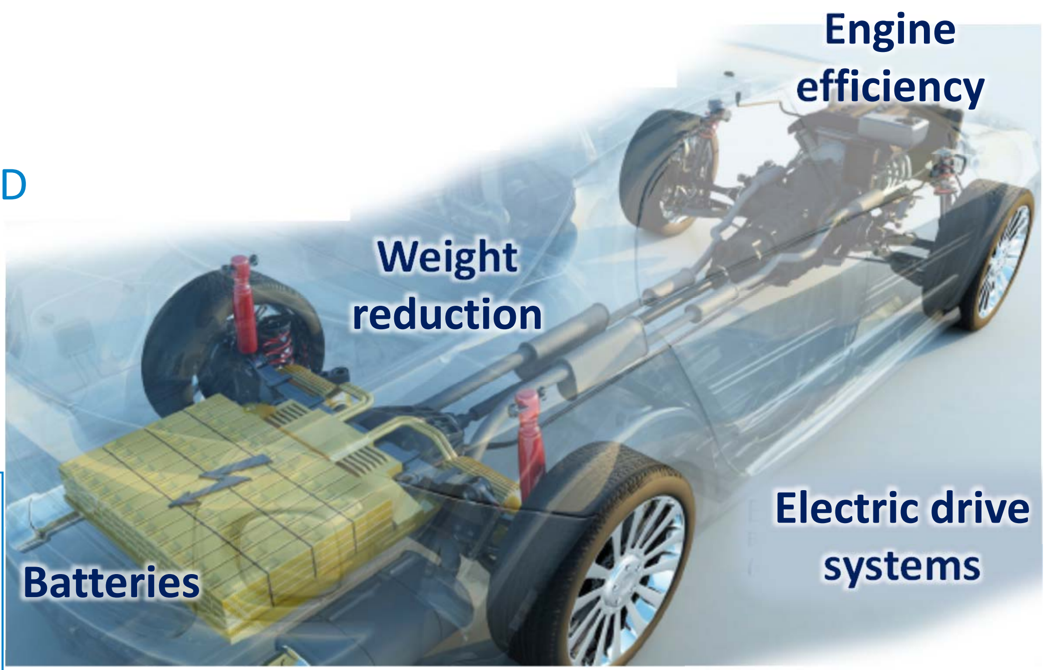
VTO targets for subprograms:

- Adv. combustion engines and fuels R&D
- Electric drive and batteries R&D
- Materials R&D
- Fuels and Lubricants R&D

For light-duty and heavy-duty vehicles

Addressing technical barrier:

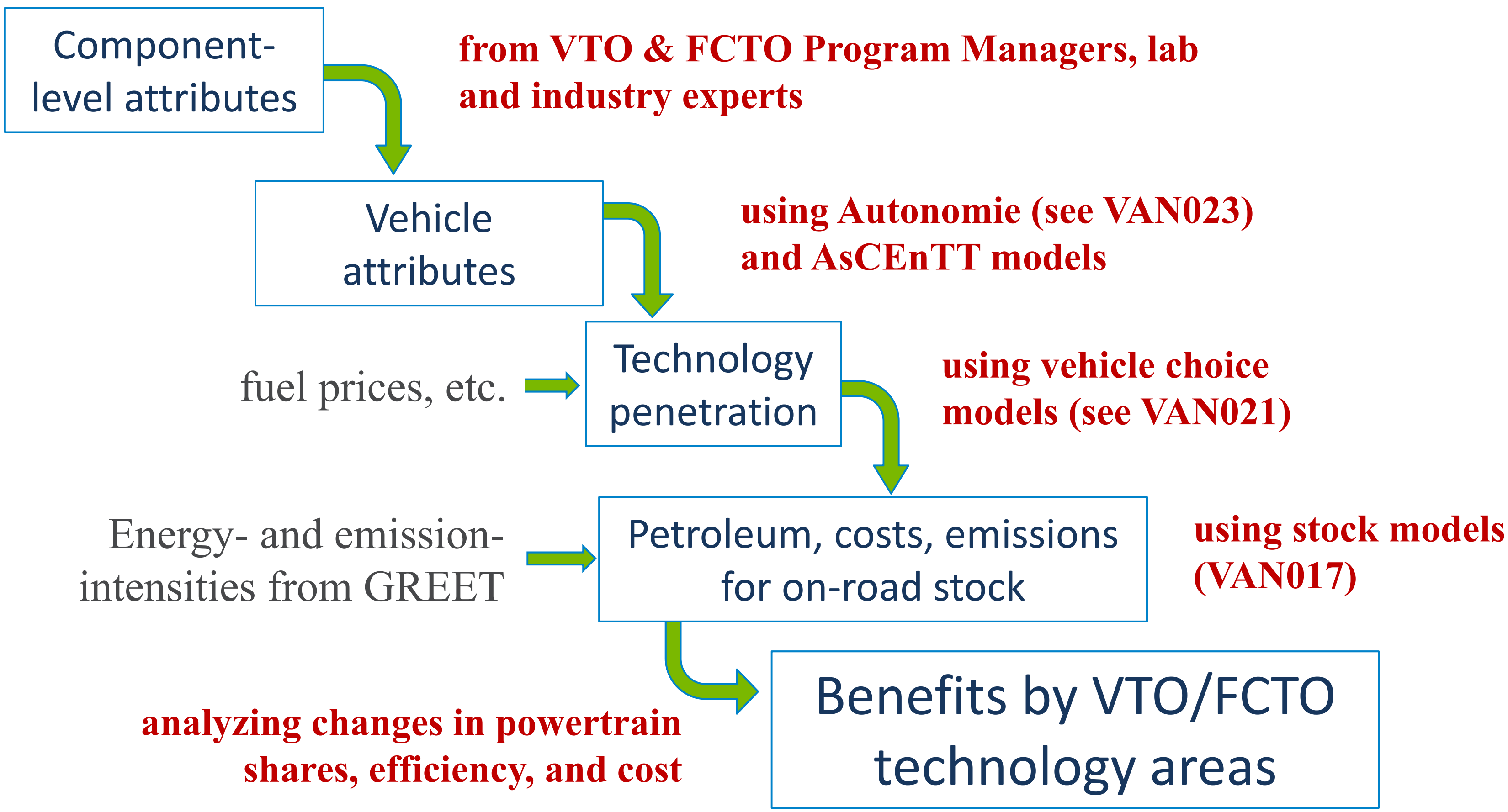
Relating component-level technologies to national-level benefits



Light-duty vehicle simulations performed by ANL Autonomie Team (see presentation #VAN023)
Heavy trucks analyzed by Energetics Inc. using AsCEnTTand TRUCK models

Connecting program goals to on-road energy use and GHG emissions

Incorporate information from across analysis portfolio

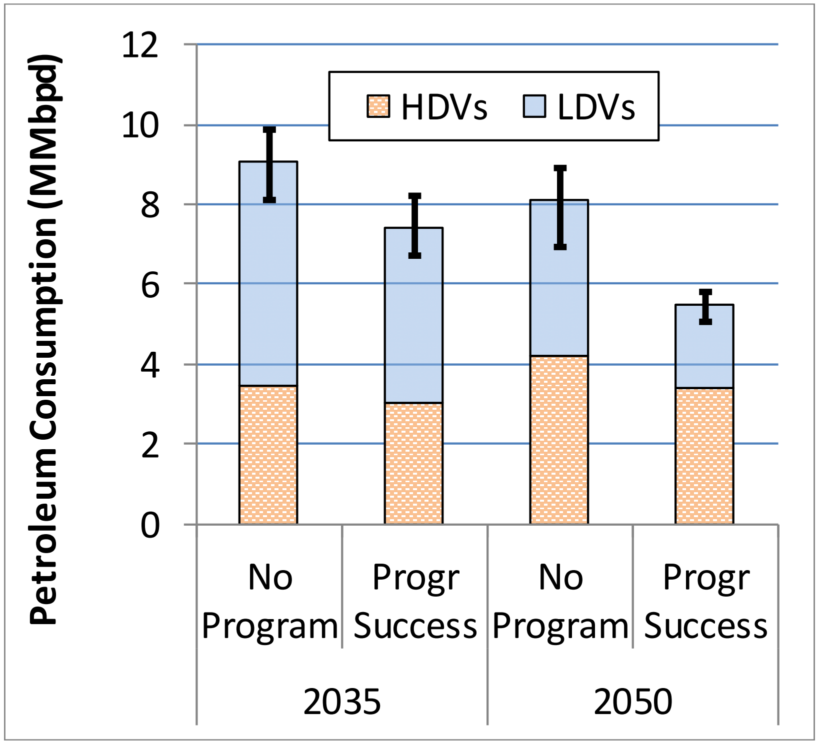


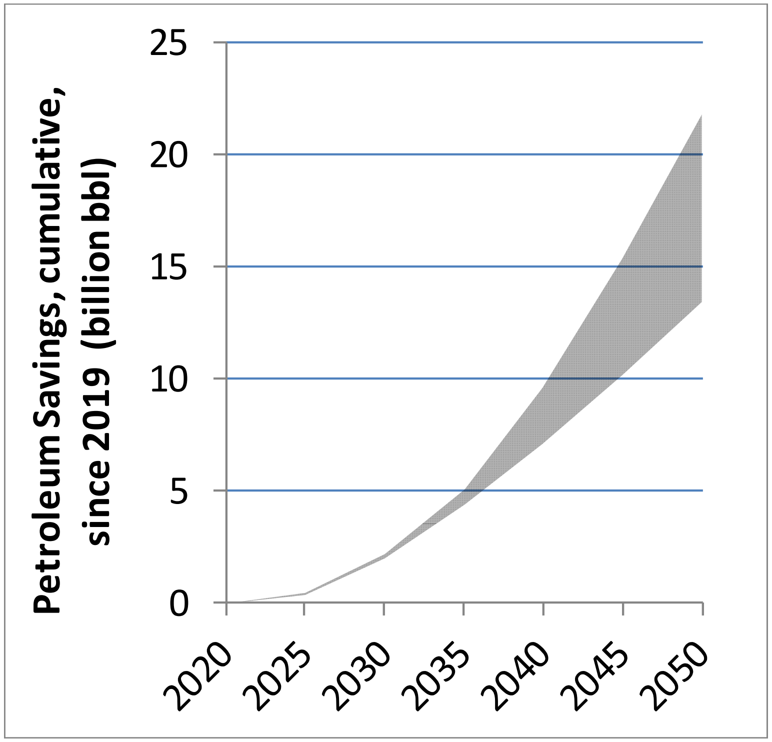
MILESTONES

Month/year	Description	Status
Dec 2017	Documentation for a plan for alternative VCM runs	Complete
Mar 2018	Report/presentation on side cases	Complete
Jun 2018	Presentation to VTO on market penetration projections	In progress
Sep 2019	Estimate national-level benefits for future target	On track

Accomplishment

Potential future petroleum savings are significant and increase over time





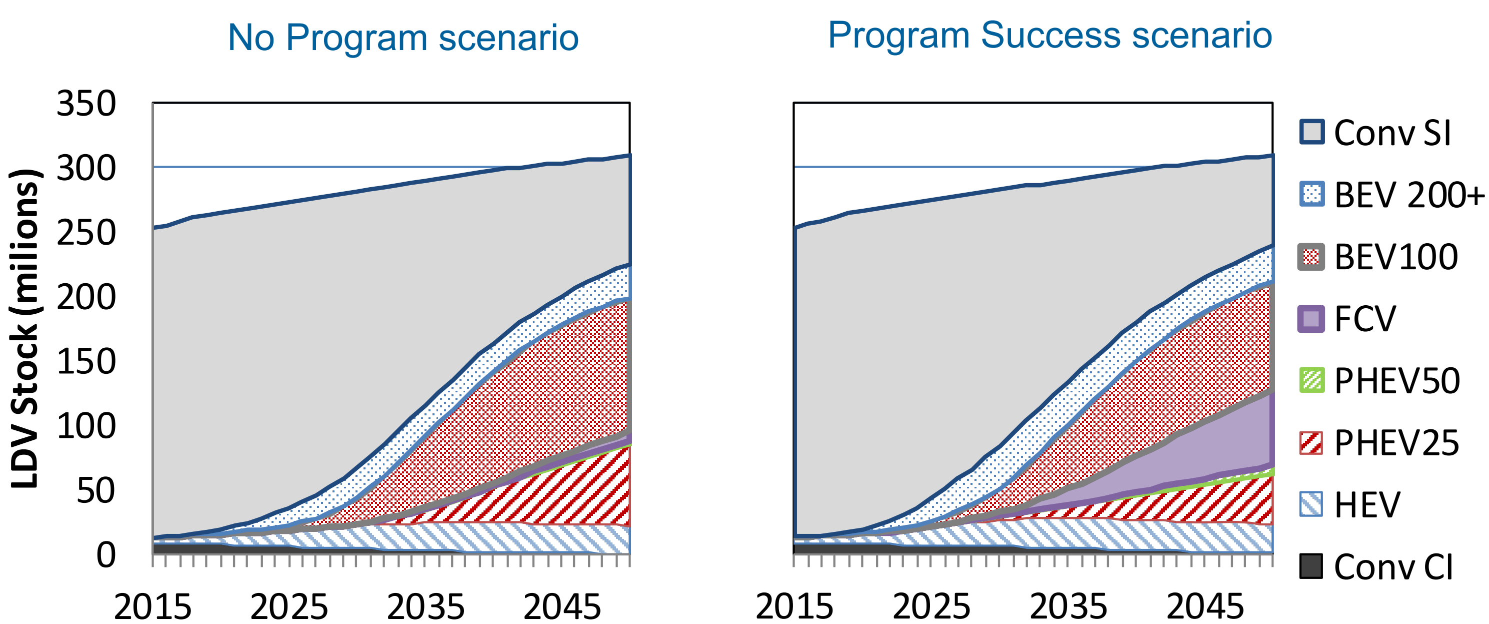
- Potential petroleum savings attributed to successful DOE R&D *and commercialization* of advanced vehicle technologies
- Error bars show range of petroleum use (from different LDV adoption models)

Approach

Vehicle choice modeling

- Estimated range of future mix of drivetrain types on the road out to year 2050
- Several sets of market shares developed using multiple consumer choice models
  – **MA³T** (ORNL), **LAVE-Trans** (ORNL), **ParaChoice** (Sandia), & **LVCFlex** (Energetics)
- Multiple possible future penetration estimates used to assess uncertainty in future stock

***Example:* Stock mix from MA³T model (and VISION model)**



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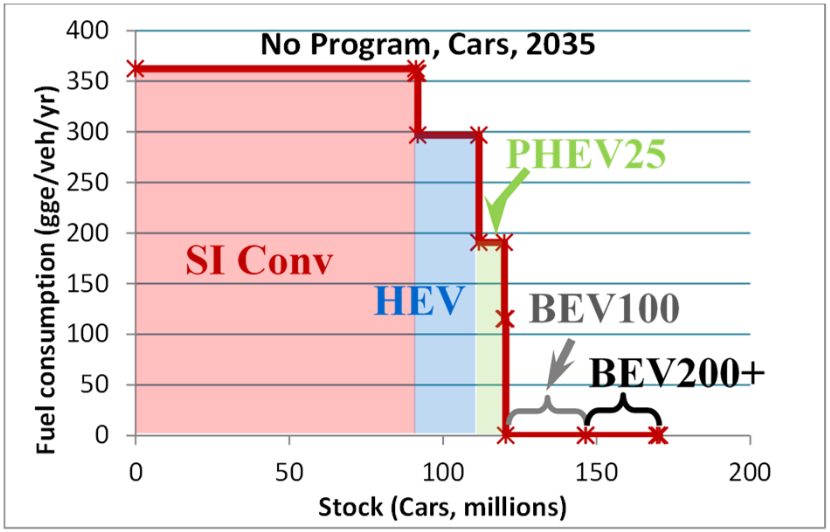
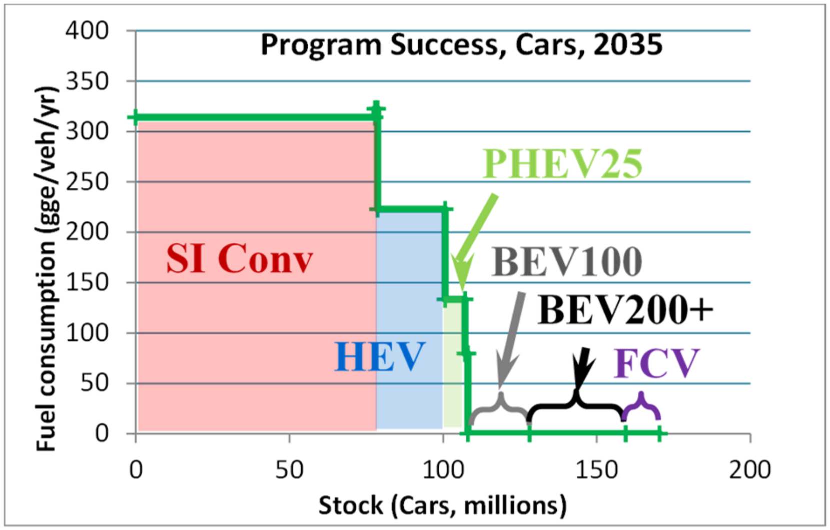
Approach

Disaggregating fuel consumption

- Fuel consumption by drivetrain type
- Fuel savings due to
  - Improvements in efficiency of each powertrain type
  - Change in mix of powertrains in the on-road fleet

***Example:* Petroleum consumption by cars in 2035 (MA³T & VISION)**





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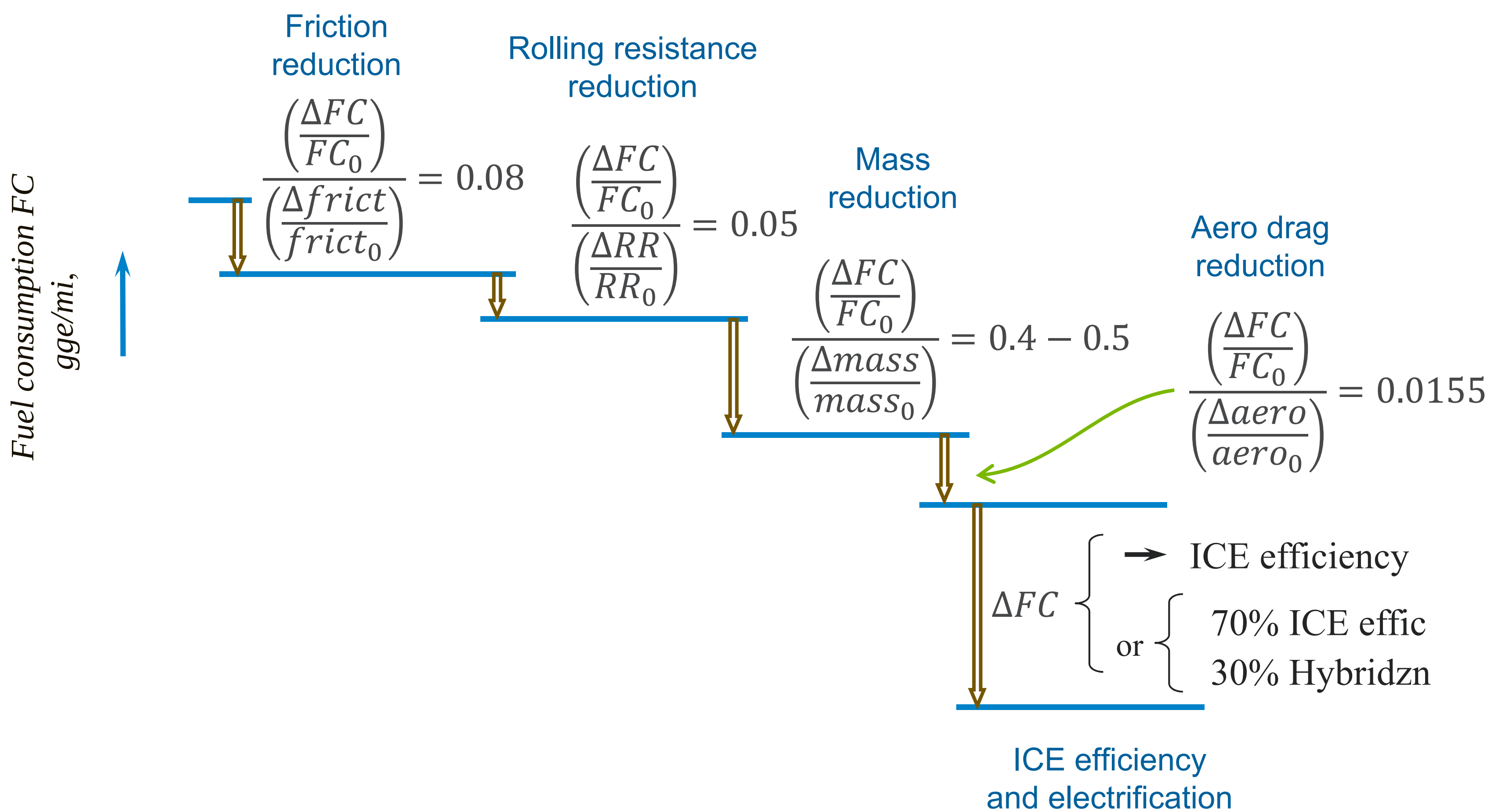
Fuel savings from drivetrain improvements by technology

Approach

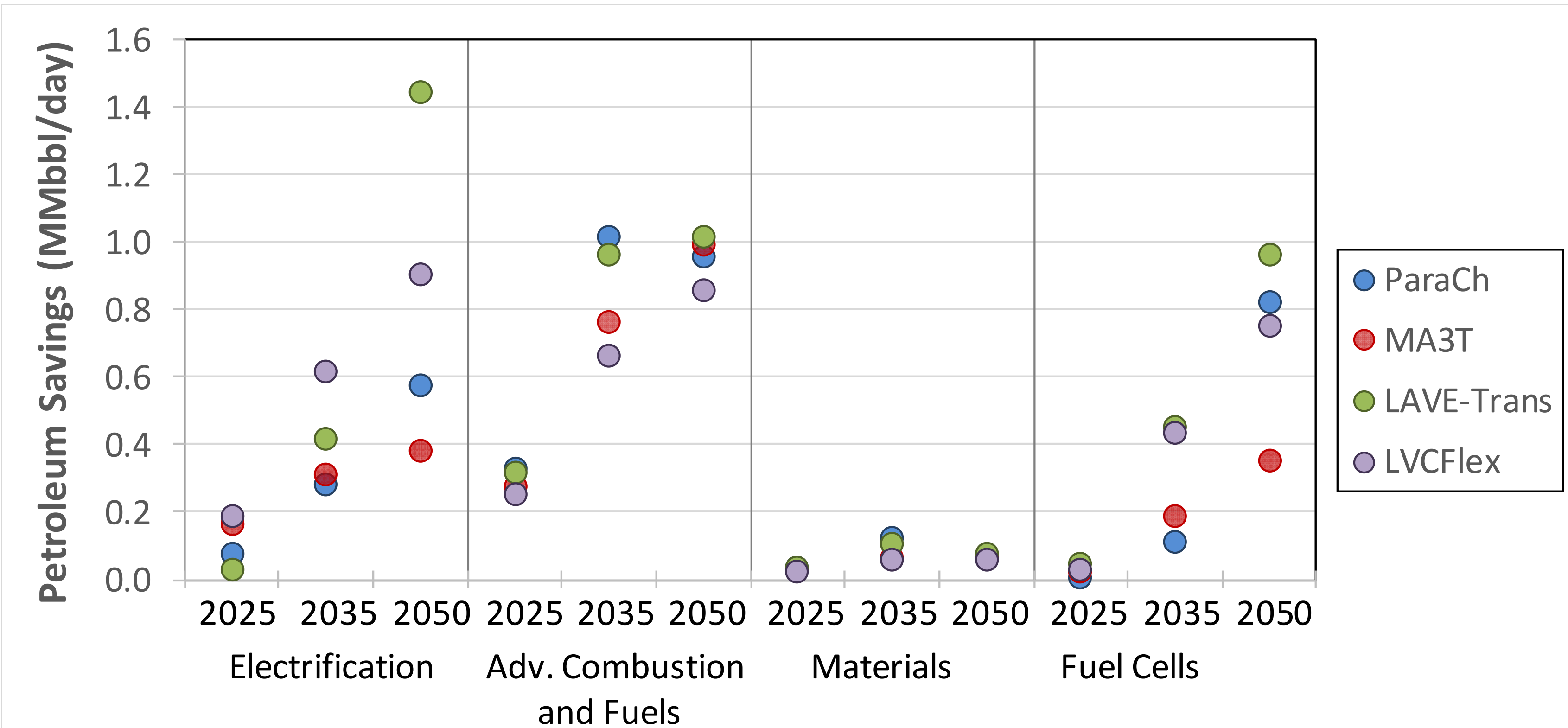
- Reduction in fuel consumption per mile by different technological improvements

Each applied in turn:



Accomplishment

Potential future petroleum savings attributed to subprogram technology areas



- More disaggregated estimates are more sensitive to different possible future adoption rates
- Heavy-duty fuel savings are included in Adv. Combustion and Fuels
- Savings due to electrification and fuel cells grows over time

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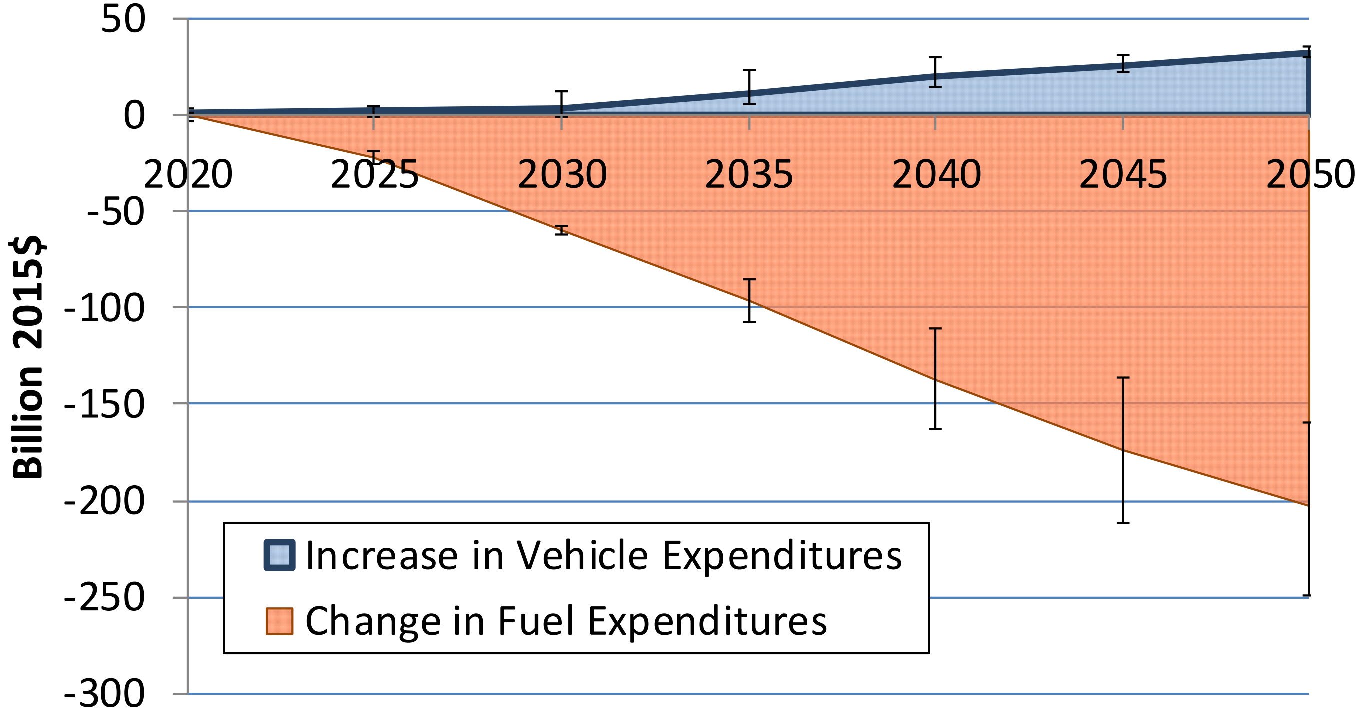
Accomplishment

VTO/FCTO funded research, *commercialized and adopted at scale*, can lower cost to consumer for vehicle operation

Differences in vehicle and fuel expenditures, light-duty, medium- and heavy duty (Program Success – No Program)



- More advanced vehicle technologies make vehicle more expensive, but fuel savings outweigh the increase in vehicle purchase cost
- Error bars show ranges based on multiple stock mixes of light-duty vehicles

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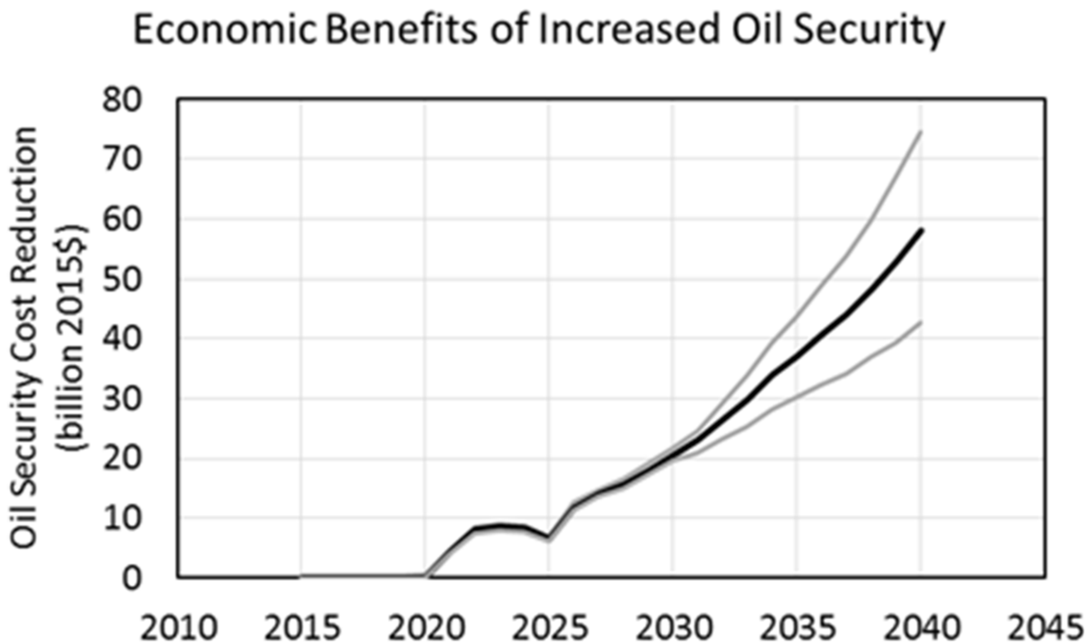
Accomplishment

Reducing petroleum use yield oil security benefit



Oil security costs:

- Transfer of wealth
- Economic surplus losses
- Macroeconomic disruption costs (impact to gross domestic product)

- Analysis of oil security benefit by Oak Ridge National Laboratory using the Oil Security Metrics Model
- Error bars show ranges based on multiple stock mixes of light-duty vehicles

Responses to Previous Reviewers' Comments (2017 AMR)

Comment: "… the reviewer wonders what the hydrogen (H_2) cost is in 2025 and what the basis is. … The reviewer observed that this does not seem consistent with the latest records from the Fuel Cell Technologies Office (FCTO), …"
Response: H_2 prices assumed were based on the low end of the range of prices in the Program Record. Side cases with somewhat higher H_2 prices were analyzed.

Comment: "… the current analysis approach assigns all fossil energy improvements to VTO-funded R&D and ignores corporate average fuel economy (CAFE)/GHG standards through 2025."
Response: Estimates were compared with the AEO2016 Reference case which assumed CAFE/GHG standard compliance through 2025. Differences were modest and significant only in the near-to-mid term.

Comment: "… the baseline is highly suspect and is predicated on an internal belief and understanding within the DOE of technology improvement, without considering private market, university, and other driven technology development. This black and white approach to technology development is problematic, particularly because a lot of DOE investments empirically demonstrated over several decades are duplicative and/or lag behind privately generated technology advancement."
Response: Results are intended to represent plausible future outcomes, not predictions. The Baseline case represents a future in which vehicle technology improves significantly, but more slowly than the Program Success case, based on VTO technology managers' inputs.

Collaboration and coordination

- Oak Ridge National Laboratory, Sandia National Laboratory, Energetics Inc collaborated on light-duty technology penetration modeling
- Energetics Inc analyzed medium and heavy-duty vehicle fuel economy improvements, technology penetration, and fleet-level benefits
- Oak Ridge National Laboratory collaborated on oil security metrics analysis
- Collaborating with Lawrence Berkeley National Laboratory and University of California at Berkeley on more comprehensive cost metrics and interactions between plug-in vehicles and the electric grid

Future work

Remaining challenges and barriers

- Update analysis base on updated inputs from VTO
- Examine uncertainties/sensitivities to assumptions about individual technologies
  - Instead of all technologies reaching “Program Success”, examine the influence of individual technologies and combinations on potential benefits
- Incorporate more comprehensive costs and benefits
  - PEV-grid interactions
  - Ownership costs

Any proposed future work is subject to change based on funding levels.

Proposed future work

- Complete updated analysis of VTO technologies in medium- and heavy-duty vehicles
- Complete analysis of side cases for light-duty vehicles
  - Examining sensitivities to cost assumptions
- Examine uncertainties/sensitivities to assumptions about individual technologies
  - Automate/streamline analysis process to analyze many (hundreds) of combinations
- Incorporate more comprehensive costs and benefits (in collaboration with Lawrence Berkeley National Laboratory)
  - PEV-grid interactions
  - Ownership costs
  - External costs

Any proposed future work is subject to change based on funding levels.

Summary: Successful development and deployment of VTO technologies can reduce costs and petroleum use

- Providing estimates of the potential future impacts of advanced vehicle technologies being developed under VTO R&D programs
- Scenarios link specific program targets and on-road future benefits component-level => vehicle-level => on-road stock
- Significant benefits from VTO technologies
  - Elucidates the contribution of VTO (by technology) to EERE mission
  - Provide quantitative results to communicate the impacts of VTO technologies
- Proposed future work:
  - Complete ongoing analysis, in collaboration with other labs
  - Examine side cases to assess sensitivities and understand technology interactions

Relevance

Approach

Accomplishments

Future work

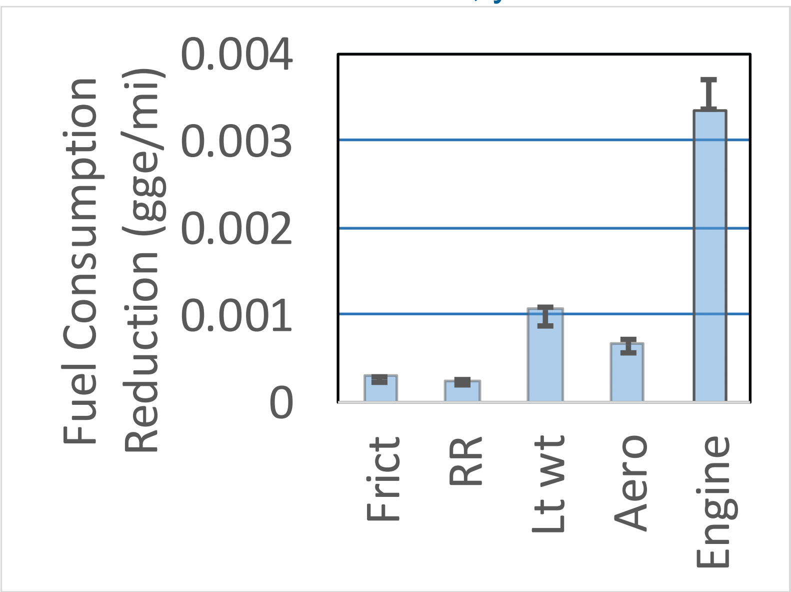
Any proposed future work is subject to change based on funding levels.

Technical backup slides

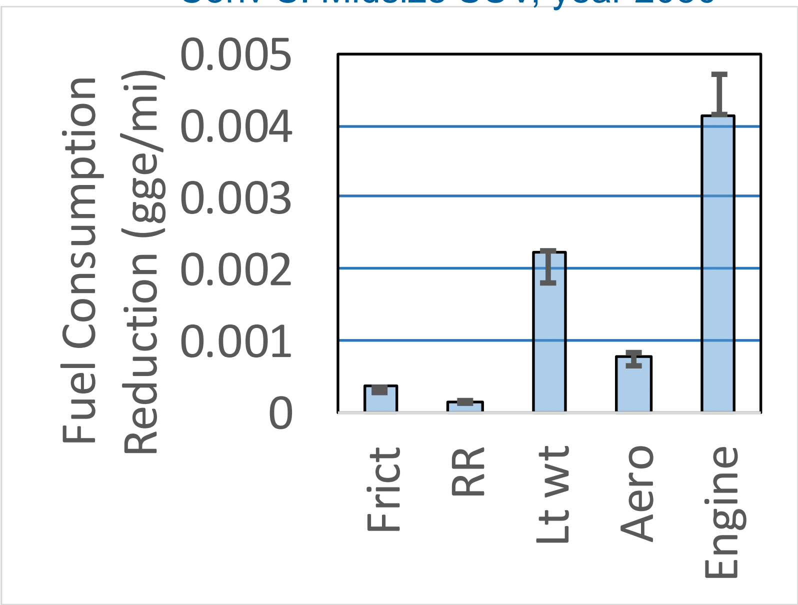
Accomplishment

Magnitude of fuel savings attributed to individual technologies is not highly sensitive to the order in which they are applied

Conv SI Midsize car, year 2035



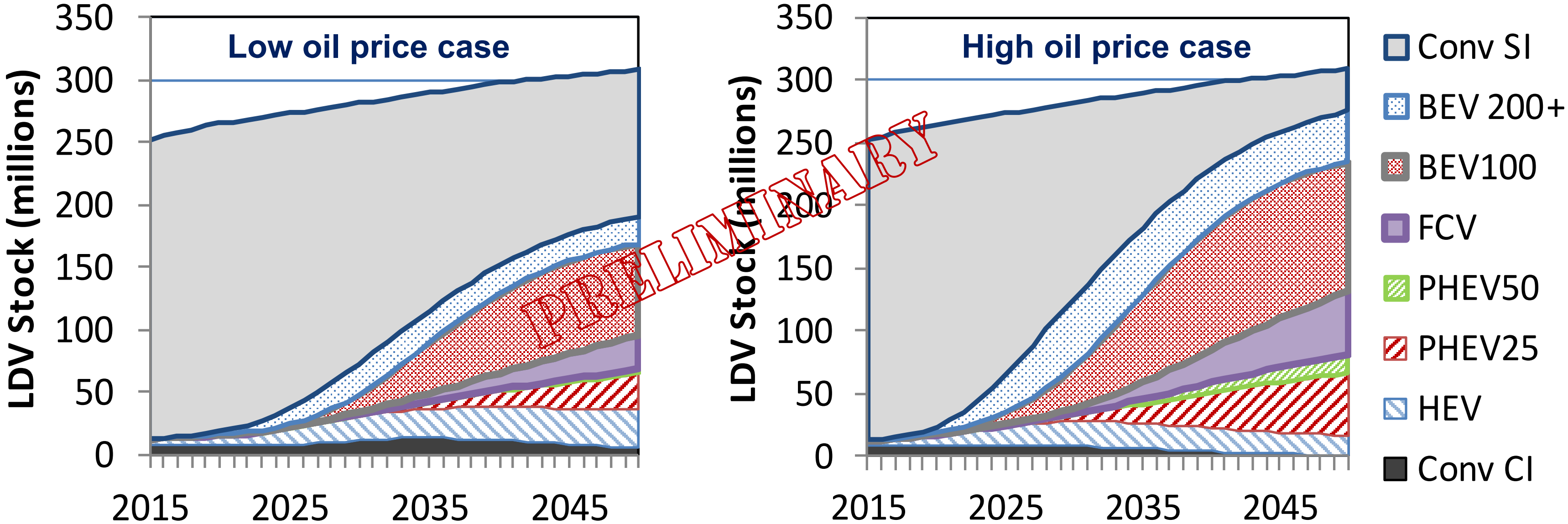
Conv SI Midsize SUV, year 2050



- Error bars show ranges of incremental reduction in fuel consumption assuming different orders
- Differences due to assumed order are small
- Largest ranges are for technologies that reduce fuel consumption the most

Low and High Oil Prices: On-road Light-duty Vehicle (LDV) Stock by Powertrain

MA3T LDV stock projections (Zhenhong Lin, Fie Xie, ORNL)



- Shares depend strongly on future fuel prices
- Only one vehicle choice model run, MA3T (will also run cases using the ParaChoice model)
- Also examining sensitivities to vehicle technology cost assumptions